

Report for 2004AZ68G: Forward and Inverse Transient Analytic Element Models of Groundwater Flow

There are no reported publications resulting from this project.

Report Follows

Mr. Kris Kuhlman, a doctoral student in the department of Hydrology and Water Resources, has been appointed Research Associate to work on this project. Much of the work described below has been accomplished by him under the supervision of the PI in consultation with our USGS co-PI, Dr. Paul A. Hsieh. Dr. Hsieh visited us to discuss the project on January 7, 2005.

Work began by conducting a thorough literature survey to establish the state-of-the-art analytic element modeling (AEM) of steady-state and transient groundwater flow problems. We have also conducted a review of numerical inverse Laplace transform methods. The latter review has benefited greatly from a face-to-face discussion of the topic with Dr. Knight, an expert in this field who has been visiting the University of Arizona. It has become clear to us that no numerical inverse Laplace transform algorithm is ideal for all function types we wish to handle, yet the algorithms we have been considering (developed in part by Dr. Knight) should work well for most if not all of these functions.

To date we have implemented steady-state and transient versions of an AEM program with circular inclusions of material having properties other than the background material (circular inhomogeneities). Our purpose in implementing a steady state version was to benchmark our approach against other existing AEM codes such as Tim^{ML}. We explored and developed theoretical approaches for the use of circular and spherical inclusions under steady-state to prescribe hydraulic head and flux at material boundaries. Our current implementation of this idea makes it possible to nest point and circular elements inside circular elements, allowing us to consider finite domains, a capability that standard AEM methods do not possess. We started extending the idea to transient flow and developing a corresponding theory for elliptical and ellipsoidal inclusions.

Our numerical implementation has thus far been done using Matlab, but we plan to convert all our algorithms into the Fortran-90 language. In preparation for this conversion, we have investigated the Fortran implementation of several special functions (Bessel and Mathieu) and of the inverse Laplace transform, all needed for the final working implementation of our Laplace transform based AEM approach.